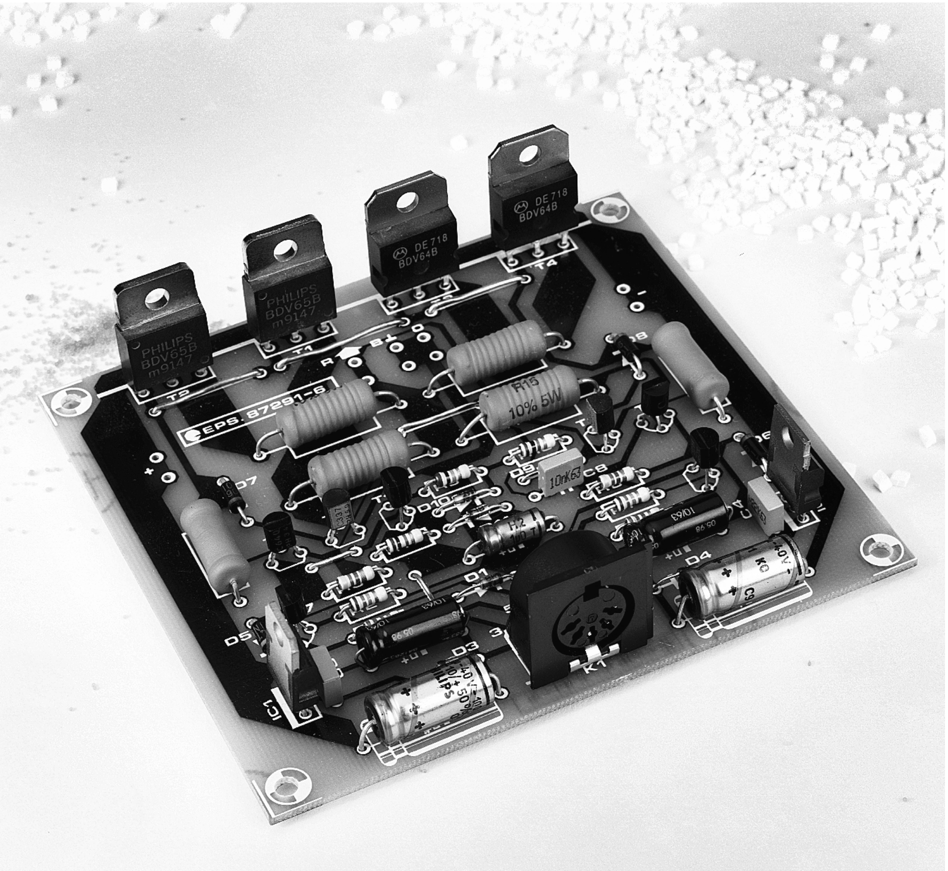
PC-controlled model railway: EEDTS Pro

the booster amplifier

The controller of a model railway is the generic term for the device used to vary the supply to the track, and thus to the locomotives, so that control of their movement is possible. It may take many forms, and may or may not contain a booster amplifier. The booster amplifier described in this article is an updated version of the one originally published in the September 1989 issue of this magazine

Design by L. Lemmens



INTRODUCTION

The booster amplifier described in this article is an updated version of the 'booster unit' described in an article published ten years ago. However, the update is minimal and consists of replacing the original Type BDV64 and BDV65 power transistors by the currently more readily available Types BDW83 and BDW84.

DESCRIPTION

Since the switching pattern of the track voltage contains control data, it is important that the booster amplifier provides a clean output signal. Much attention has, therefore, been paid to the switching speed. The use of emitter follower output stages enable higher switching speeds since the transistors, T_1–T_4 (see **Figure 9**), operate on the linear part of their characteristic. This means that the switching speeds are not affected by saturation effects.

The bases of the emitter followers are switched by drivers T_5 and T_6 between +20 V and –20 V. These voltages are provided by IC_1-D_3 and IC_2-D_4 respectively. The final output voltage is the difference between the base voltage and the sum of the base-emitter potential (about 1.5 V) of the output transistors and the drop across the emitter resistors (maximum 0.6 V).

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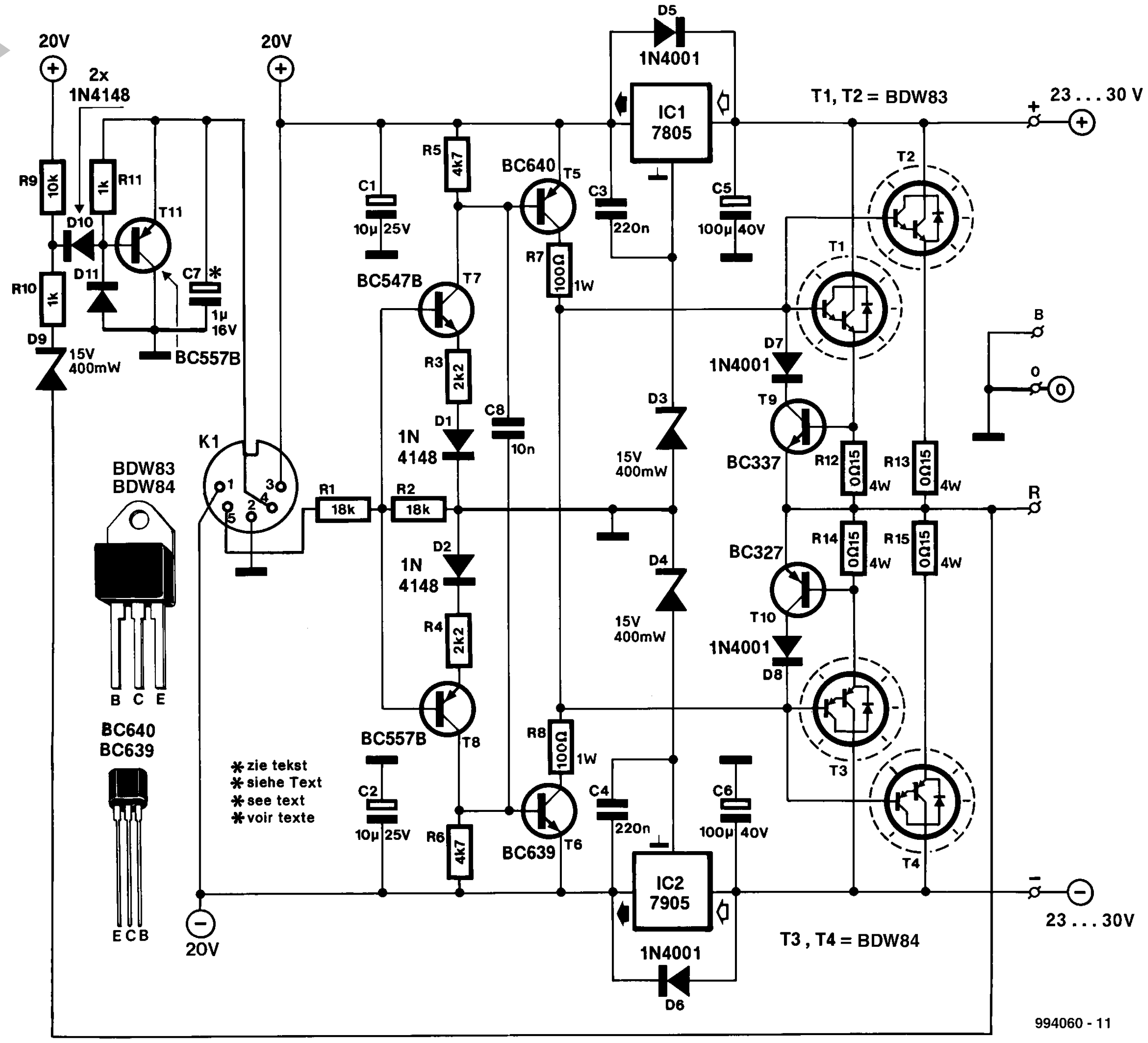

Figure 9. Circuit diagram of the booster amplifier. Power transistors T1–T4 have been replaced by current types BDW83 and BDW84.

In practice, the output voltage is a reasonably constant ±18 V.

The emitter followers ensure better bandwidth and regulation with complex loads than would be obtained with feedback.

Emitter resistors R_{12}–R_{15} ensure an equal division of the current to T_1-T_2 on the one hand and T_3-T_4 on the other.

Resistors R_{12} and R_{14} serve to measure the current in aid of short-circuit protection transistors T_9 and T_{10}. When the emitter current of T_1 or T_3 tends to become excessive, the drop across R_{12} or R_{14} rises sufficiently to switch on T_9 or T_{10}. This results in a reduction in the base current of the output transistors and, consequently, in their collector and emitter currents.

The input stage is formed by T_7 and T_8, and is configured in a manner that makes a balanced input signal essential. When the input (pin 5 of K_1) is 0 V or not connected, all transistors are off and the output presents a high impedance, that is, there is no voltage supplied to the track. When the input voltage is between +5 V and +20 V, transistors T_1, T_2, T_5, and T_7, are on and the output is switched to +18 V. With the input voltage between –5 V and –20 V, transistors T_3, T_4, T_6, and T_8, are on and the output is switched to –18 V.

All transistors, except T_5 and T_6, operate on the linear part of their characteristics. Transistors T_5 and T_6 are switched in the saturation region

Figure 10. Circuit diagram of a suitable power supply for the booster amplifier; other designs are, of course, possible.

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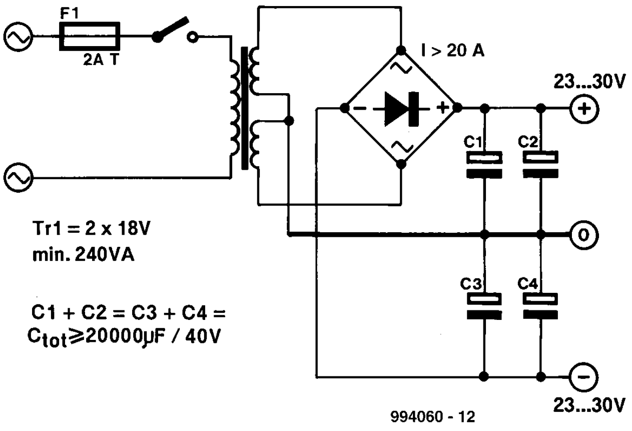

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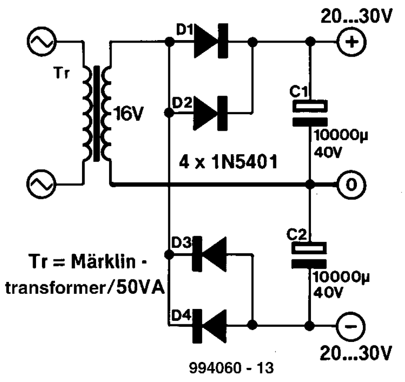

Figure 11. Alternative power supply for use where a suitable mains transformer is already available. See reservations about this in the text.

because switching transistors for voltages of 50 V or more are not available. Nevertheless, capacitor C_8 ensures that these transistors switch at a sufficiently high speed.

OVERLOAD

The circuit around T_{11} serves to indicate an overload condition. Note that only the negative output voltage is monitored, which is sufficient since the

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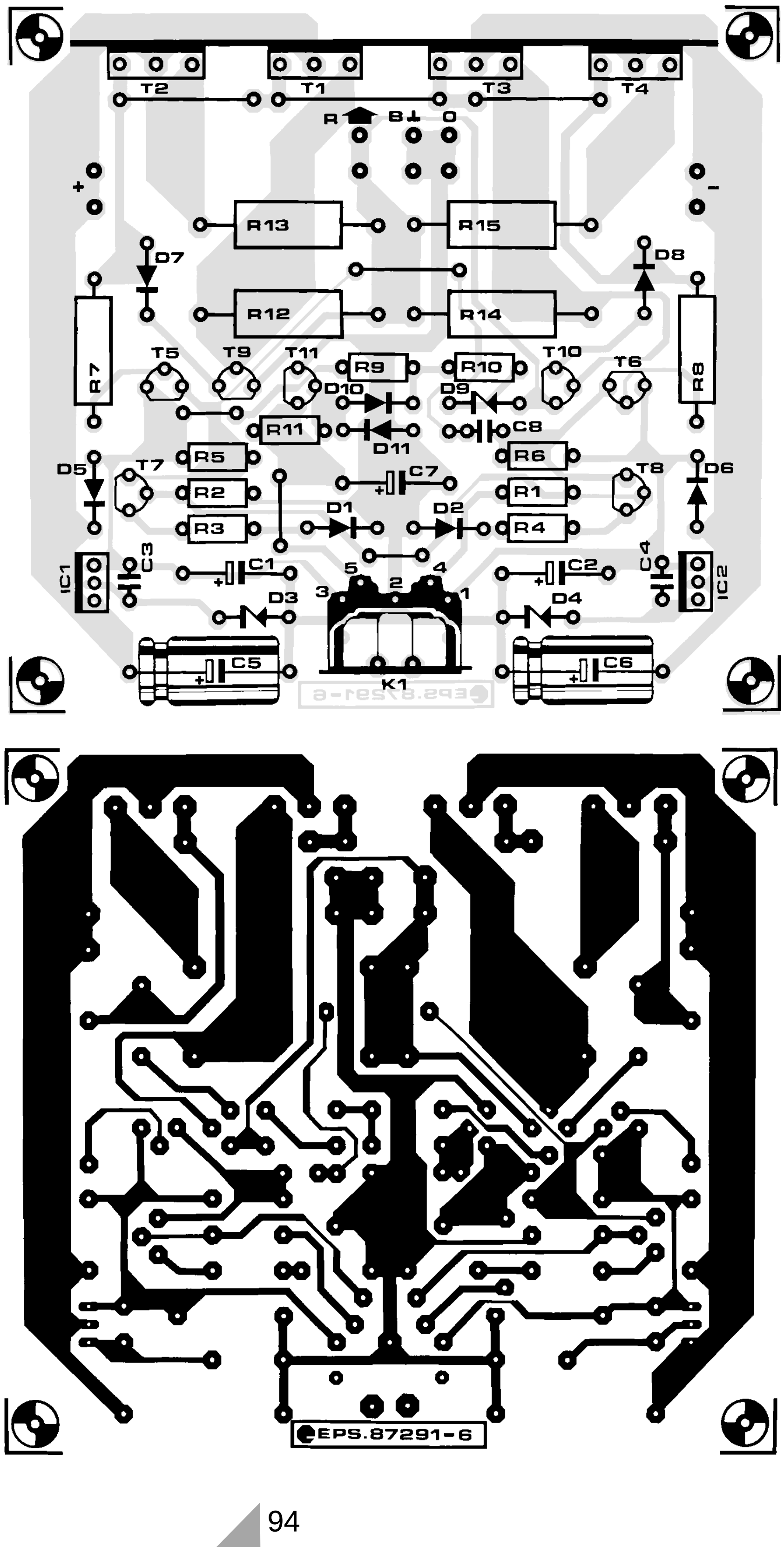

Figure 12. The printed-circuit board for the booster amplifier is available ready made – see Readers' Services towards the end of this issue.

Parts list

Resistors:

R_1, R_2 = 18 kΩ
R_3, R_4 = 2.2 kΩ
R_5, R_6 = 4.7 kΩ
R_7, R_8 = 100 Ω, 1 W
R_9 = 10 kΩ
R_{10}, R_{11} = 1.0 kΩ
R_{12}–R_{15} = 150 mΩ, 4 W

Capacitors:

C_1, C_2 = 10 µF, 25 V
C_3, C_4 = 0.022 µF
C_5, C_6 = 100 µF, 40 V
C_7 = 68 µF, 16 V
C_8 = 0.01 µF

Semiconductors:

D_1, D_2, D_{10}, D_{11} = 1N4148
D_3, D_4, D_9 = zener 15 V, 400 mW
D_5–D_8 = 1N4001
T_1, T_2 = BDW83 (Philips)
T_3, T_4 = BDW84 (Philips)
T_5 = BC640
T_6 = BC639
T_7 = BC547B
T_8, T_{11} = BC557B
T_9 = BC337
T_{10} = BC327

Integrated circuits:

IC_1 = 7805
IC_2 = 7905

Miscellaneous:

K_1 = 5-way DIN socket (180°) for PCB mounting – but see text
5 off car-type space terminals for PCB mounting
Insulation material for T_1–T_4 and their heat sink
Heat sink 0.8 K W^{-1}
PCB Order No. 87291 (see Readers Services towards the end of this issue)

Parts for recommended power supply

(not on booster board!)
Mains transformer, 2×18 V, 300 VA
4 off smoothing capacitors of 10,000–15,000 µF, 40 V
Heavy-duty bridge rectifier
Fuse holder with 2 A slow fuse for board mounting

load on the negative supply line is slightly higher than that on the positive line. For instance, the turnout (points or switches) decoders work with half-wave rectifiers and, therefore, load only the negative line. Moreover, when there are no data being transmitted, the output voltage is negative.

When the booster amplifier is overloaded, T_9 and T_{10} limit the current in the first instance. The output voltage then drops significantly and this causes a rise in the potential across the output transistors and, consequently, in the dissipation. If this situation is allowed to persist, there is a danger of the booster amplifier being thermally overloaded, which presents a real risk of fire.

Therefore, if the output voltage drops below 15 V, owing to the zener voltage of D_9, T_{11} switches off. The signal at pin 5 of K_1 goes low, which results in the removal of the drive to the controller..

Capacitor C_7 enables the overload action to be delayed so that the system is not disabled at every momentary short circuit.

CONSTRUCTION

If the printed-circuit board in **Figure 12** is used, construction of the booster amplifier should not present any undue problems. Fit the wire links first: those close to the output transistors should be of 1 mm dia. wire.

Mount resistors R_{12}–R_{15} well away from the board, because they become pretty hot during operation.

The board has provision for a 5-pin DIN connector, but if the controller is to be used in a stationary position, which is normally the case, the respective wires may be soldered directly to the board.

Circuits IC_1 and IC_2 do not need a heat sink, but transistors T_1–T_4 do: this should be rated at $0.8\ K\ W^{-1}$.and be used with good-quality insulating washers and spacers, and liberal use of heat conducting paste.

IMPORTANT

If the booster amplifier is to be used with the controller described in last month's issue, it must be linked to this via the interface described in that issue.

POWER SUPPLY

The circuit diagram of a suitable power supply is shown in **Figure 10**. The mains transformer should preferably be a toroidal type approved to Class I. This means that the mains cable must have three cores, one of which is to be connected to the protective earth of the mains supply. All metal parts that can be touched (incl. the heat sink) must be connected to this earth.

The rectifier must be a heavy-duty type and needs a heat sink: it may be mounted on that used in the booster amplifier (T_1–T_4).

Connect the two secondary windings of the transformer in series and fit and solder the rectifier and the buffer capacitors.

If a suitable transformer is already available, this may be used to build a power supply as shown in **Figure 11**. Note, however, that such a setup will normally not be able to provide more than about a quarter of the power of the design in Figure 11.

Finally, do not connect transistors in parallel to increase the total available current: such a setup can be a risky undertaking.

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